ORBITAL OPERATIONS STUDIES

Natural Resources Research Institute

in association with the

National Aeronautics and Space Administration

College of Engineering

University of Wyoming

Laramie, Wyoming

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June 21, 1971

Final Report
NASA Grant ~~NsG 658~~ NQR-51-001-001

ORBITAL OPERATIONS
STUDY

June 1971

Office of Grants and Research Contracts
National Aeronautics and Space Administration
Washington, D.C. 20546

Gentlemen:

The following final report summarizes our work under Grant No. NsG-658 for an Orbital Operations Study. The enclosed technical reports entitled

"Environmental Aspects of the Units Problem," and

"Proposed Geo-Altitude Coordinates of Vertical Positions"

comprise the major accomplishments of this study and are currently being submitted for publication elsewhere. In addition, the enclosed report on

"Geosection Indices for Environmental Data"

has evolved from work that was initiated under the subject contract.

We at the University of Wyoming have deeply appreciated this opportunity to help contribute to the development of aeronautical and space operations, and hope that the results presented in these reports will prove to be as useful as they promise to be.

Sincerely,

John C. Bellamy

John C. Bellamy
Director

FINAL REPORT NGR ~
NASA Grant No. ~~NsG-658~~ 51-001-001
ORBITAL OPERATIONS STUDY

Submitted by
John C. Bellamy, Director
Natural Resources Research Institute

This final report of accomplishments under the subject grant was originally planned to have been written following a conference here at the University of Wyoming with personnel from the Goddard Space Flight Center and NASA Headquarters concerning their potential applicability to specific NASA problems. That conference was scheduled for October 1967, was postponed three times and was eventually cancelled, since by then most of the people involved had left the University. In the meantime, diligent efforts have been continued to produce meaningfully useful reports on the "nautical units" that were being developed under the subject grant for coordinating the space-time positions of things throughout the Earth's atmosphere and the Earth-centered region of space — and have finally resulted in the two technical reports that are being forwarded herewith as the major accomplishment of the work sponsored by this grant.

Personnel

The major portion of the funds of this grant were expended for the following numbers of man-months of effort by the following personnel between the May 14, 1966 close of the last-reported period and their exhaustion in October 1967.

Staff

John C. Bellamy, Director, Professor of Civil Engineering	(5.5)
R. Kenneth Beach, Professor of Electrical Engineering	(2.0)
C. Norman Rhodine, Associate Professor of Electrical Engineering	(10.5)
Javin N. Taylor, Instrumentation Engineer and Instructor	(7.5)
Robert V. Courter, Research Engineer	(2.5)

Edward Mastascusa, Research Engineer	(5.5)
Anton Munari, Research Engineer	(2.5)
Robert Wheasler, Research Engineer	(0.5)
William W. Holland, Jr., Model Maker	(3.5)
Howard F. Guill, Mechanical Technician	(3.0)
Howard E. Roberts, Mechanical Technician	(2.0)

Graduate Research Assistants

David Fjell, Math	(4.5)	Johan Dahl, C.E.	(1.0)
Larry Bruce, E.E.	(1.0)	Douglas Campbell, C.E.	(1.0)
Russell Chadwick, E.E.	(1.0)		

Technical Accomplishments

In brief summary, this overall Orbital Operations Study has consisted of the following three quite different but closely interrelated kinds of research.

ANALYTICAL TECHNIQUES

One of the most difficult aspects of the field of "Orbital Operations" is to be able to analyze the functional relationships among its many component elements, including especially among separately organized and controlled activities such as among the major subdivisions of NASA, DOD, the Universities and Private Industry. A novel overall framework for such analyses was established and described in Progress Report No. 1 entitled "Plan of Study" – and is recommended as a very good starting point for such analyses.

These analytical techniques highlighted a need for an explicit identification of the region with which Orbital Operations are primarily concerned – namely that airless but "full-of-fiery-energy" or "Pyrospheric" portion of the Earth-centered Geosphere within which permanent orbits of satellites around the Earth can exist. That Pyrosphere and/or Geosphere were shown in Technical Report No. 3 on "The Character of Gravispheres" to extend to about 235 Earth-radii at slightly less than 4 times the distance to the Moon and at very nearly 1/100 of the distance to the Sun – at which radius the net gravitational field in an Earth-Sun coordinate system ceases to be Earth-centered.

INFORMATIC FORMS OF DATA AND EQUIPMENTS

The analysis in the Plan of Study also clearly showed that the separately organized aspects of Orbital Operations are interrelated almost entirely by the data that they interchange — and that it should be possible to develop and utilize much more effectively useful forms of such data now that it is possible to acquire, process and portray it automatically. Most of the efforts of the subject grant were directed toward this end, and resulted in Technical Reports Numbers 4, 5 and 6 entitled:

"1965 Status of TACOS, An Experimental Tabular Computing System";
"An Initial Use-Test of Triadic Digits"; and
"A Triadic Decimal Digit Printer-Reader Unit".

These reports essentially described the initial phase of a succession of trial-and-error postulates and tests of those forms of orbital data portrayals which might best be formed automatically and those necessarily new kinds of equipment that can form and/or read them for automatic reprocessing. As might well have been expected, these initially postulated kinds of equipment and "triadic" forms of numerals proved to require further development before they could be considered to be as useful as they might well become. That next round of postulation and test of improved versions of such "informatic numerals" and associated equipments had proceeded to the point that illustrative examples of their use with actual orbital data could have been made when the funds available for this work were exhausted.

Although this work could not be continued far enough under this grant to provide for immediately useful application in Goddard's Control Centers, the concepts that it evoked have subsequently been put to very good use in closely related work under other auspices. Specifically, they led directly to a technical report on "Geosection Indices for Environmental Data" that is currently being submitted for publication; preprint copies of which are forwarded herewith. In addition, it led directly to the developments under Grant No. E-299-68(G)

and Contract No. E-12-70(N) of the Environmental Data Service of the Environmental Science Services Administration that are described in reports entitled:

"Informatic Index of Geomagnetic Observational Data";

"Final Summary Report, Environmental Data Format Study"; and

"Potential Methods of Indexing Diurnal Weather Observations";

copies of which can be obtained from ESSA or upon request from the Natural Resources Research Institute.

GEOSPHERIC SYSTEM OF UNITS

The analysis in the "Plan of Study" report also highlighted the need for better means to coordinate the space-time positions of space-science data and space-flight data with each other as well as with all other kinds of environmental data. Continued investigation clearly showed that the units of the metric system were not nearly as suitable as other units for this coordinative purpose. For example, the metric system does not include any of the minute, hour, day and year units of time — nor any of the second, minute, degree and circle units of angle — with which space-time positions of satellites as well as virtually all human activities are coordinated throughout the world. Neither does it include the nautical mile with which horizontal distances are coordinated in world-wide navigational and manned space-flight operations. A potential solution of this units problem was suggested in Technical Report No. 2 entitled

"Proposed Nautical Units of Length and Time"

that was published in Navigation, Vol. 13, No. 1, Spring 1966, pp 12-22.

Continued work on this units problem has resulted in the formulation of a much more widely applicable "Geospheric System of Units" for identifying the sizes, amounts and space-time positions of particular unit-things throughout the Earth-centered or Geospheric regions of the universe in coordinative ordinal-numbered relationship to each other and to characteristic features of the Earth. It has taken almost four years to complete the development and — hopefully —

a widely understandable description of this Geospheric System of Units that is forwarded herewith as a preprint of an article to be submitted for publication on the "Environmental Aspects of the Units Problem".

Of special interest to the National Aeronautics and Space Administration, this Geospheric System of Units was conceived primarily to provide for coordinating the vertical positions of things in and of the atmosphere within and between meteorological and aeronautical operations. Its full potential for this purpose can be realized, however, only if an "Ideal Atmosphere" counterpart of the U.S. Standard Atmosphere is also defined in more conveniently useful terms of the "geounits" of the Geospheric System. Toward this end, a report on

"Proposed Geo-Altitude Coordinates of Vertical Positions"

has been prepared and is forwarded herewith. These "altitude" coordinates are recommended to NASA for implementation in its historical role of formulating Standard Atmospheres for aeronautical purposes — and especially to serve forthcoming manned aerospaceflights through the atmosphere to and from orbital space stations.

Summary

In conclusion, we at the University of Wyoming deeply appreciate the opportunity that the subject grant has provided for us to help contribute to NASA's mission. Although the attempted development of "informatic" forms of data and equipments proved to be too difficult to complete for immediate use in current Orbital Operations under this particular grant, the development of the Geospheric System of Units might very well ultimately prove to be one of the most important generally-applicable "spin-offs" of basic applicable research work that has been funded by NASA.